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ANTI-BUCKLING DEVICE FOR THIN-WALLED FLUID DUCTS

The present invention relates to an anti-buckling device for thin-walled fluid ducts in accordance with the introductory section of claim 1.

Most closely related to the anti-buckling device in accordance with the invention is WO 01/14782 (D1). Document D1 discloses a self-adjusting segmented opening of a pipe or duct. From both sides webs are recessed asymmetrically in a pipe perpendicularly to the direction of flow. Chambers are produced in which vortices can form. The vortices influence the hydro- or aerodynamic characteristics of the pipe. For example, the mass throughflow through a pipe can be regulated. Depending on the configuration minimum and/or maximum mass flows can be set.

However, the invention disclosed in (D1) cannot guarantee a minimum throughflow if pipes or hoses are bent and buckling occurs. The webs on the internal walls even increase the tendency of a pipe to become occluded in such cases.

The present invention is intended to prevent thin-walled fluid ducts becoming buckled or constricted in tight radii, and the throughflow being impeded or even interrupted.

Fig. 1 shows a cross-section through a first example of embodiment

Figs. 2a, b isometrically show a first example of embodiment in a elongated and bent condition

Figs. 3a, b show a longitudinal section through a duct with different bends

Fig. 4 shows a cross-section through a strongly bent duct with an inserted anti-buckling device

Fig. 5 shows a front view of a buckling point

Figs.6-8 various envelopes with different cross-sections of the first example of embodiment

Figs. 9a, b show a cross-section and a top view of a second example of embodiment

Figs. 10, 11 show two variants of the top view of the second example of embodiment

Fig. 12 shows a cross-section through a third example of embodiment

Figs. 13a, b show cross-sections through a hose with a first example of embodiment

Figs. 14a, b show cross-sections through a core with a third example of embodiment

Figs. 15a, b show cross-section through core with a variant of a third example of embodiment

Fig. 1 shows a cross-section through an anti-buckling device 1 according to the invention. It is shaped in such a way that on both sides of a middle line M several ribs 2 are present. Between every two ribs 2 grooves 3 are thus formed.

The isometric view of the anti-buckling device 1 in fig. 2a shows this in an elongated, straight and thus non-functional form. The ribs 2 run parallel to each other along the entire length of the anti-buckling device 1. The grooves 3 can be seen between the ribs 2.

A bent, functioning form of the anti-buckling device 1 is shown in fig. 2b. Here the ribs 2 and grooves 3 run in parallel to each other. In order to keep deformation of the cross-section to a minimum the anti-buckling device 1 is made of an elastic material, for example an elastomer, with a hardness of between 30 and 80 Shore.

When the anti-buckling device 1 is bent, one side is always elongated and the opposite side is always compressed. The elastomer is able to permit this deformation without buckling and essentially changing its cross-section; this means that the ribs 2 and groove 3 continue to be present when the anti-buckling device 1 is bent.

Figs. 3a, b show longitudinal sections through a thin-walled duct 6 at various bending radii. In the area of the bend an elongation zone 7 occurs, with a buckling point 8 opposite it. In a strongly bent duct 6 - as shown in fig. 3b - a point can be reached at which the buckling point 8 is so compressed that it comes into contact with the elongation zone 7 thereby occluding the duct 6.

In fig. 4 an anti-buckling device 1 is inserted into a strongly bent duct 6. The buckling point 8 can now no longer reach the elongation zone 7 and the duct 6 remains open for fluids. In order to prevent buckling before and after the anti-buckling device 1 it is expedient to select the length of the anti-buckling device 1 to be approximately equal to the length of the elongation zone 7.

Fig. 5 shows a section AA in fig. 3a. The cross-section of an essentially circular duct 6 is essentially lenticular at

the buckling point 8. This shape is produced by the interaction of pressure and tensile forces in the duct bend. The elongation zone 7 is produced by tensile forces in the outer radius of the duct bend and is pulled towards the midline M, while the buckling point 8 is produced by pressure forces in the inner radius and is pressed towards the midline M. The diameter orthogonal to the midline M is thereby reduced and that along the midline M enlarged.

In both directions away from the buckling points 8 the duct 6 continuously reassumes its original cross-section, for example a circular cross-section. The inventive concept therefore includes constantly varying the envelope 4 of the anti-buckling device 1 matching it to the cross-section of the duct 5, for example from a circular to a lenticular form.

Figs. 6, 7 and 8 show various cross sections of anti-buckling devices 1 with their corresponding envelopes. With their lenticular or rhomboid shape the envelopes 4 in figs. 6 and 7 take into account the cross-section at the buckling point 8 described in fig. 5. Other envelopes 4, such as in fig, 8 with, for example, triple rotational symmetry are also of course considered to be in accordance with the invention. In general the envelopes 4 can be built up of polygonal and/or curved segments which occur by connecting adjacent ribs 2. Accordingly the shape and arrangement of the ribs 4 can be freely selected. Essential to the inventive concept is that the grooves 3 remove open and permeable when the anti-buckling device 1 is bent.

Fig. 9a shows a cross-section through a second example of embodiment of an anti-buckling device 1. The ribs 2 and grooves 3 are comparatively broader and the ribs 2 are not as high, with the grooves 3 being less deep accordingly.

The top view of 9b show that this form of embodiment allows the ribs 2 to be interrupted and thereby create transverse connections 9. The transverse connections 9 are useful in two respects. On the one hand the ribs 2 are exposed to less pressure and tension during strong bending, and on the other hand they support regular fluid throughflow as they connect grooves 3 to each other and fluid can flow around occlusions in individual grooves in the area of a bend.

Fig. 10 is a variant of fig. 9b. The transverse connections 10 are arranged in such a way that both throughflow directions essentially exhibit the same flow conditions in the anti-buckling device.

Fig. 11 shows a further variant. The ribs 2, which are not at the edge of the anti-buckling device 1 are reduced to knobs 11. In place of the grooves 3 and transverse connections 10 there is an intermediate space 12 in which a fluid can flow around the knobs 11. As a further variant it is possible to apply the knobs 11, for example by way of screen printing, to the inside of the duct wall 9. Ribs can of course also be created using the same method.

The cross-section through a third example of embodiment is shown in fig. 12. The two middle ribs are shaped so that they can hold at least one plastic pipe 13. The wall thickness of the plastic pipe13 is dimensioned in such a way that the maximum pressure and tension forces which can arise during bending of a duct 6 cannot essentially affect the cross-section of the plastic pipe. In the case of greater forces reinforced plastic pipes 13 can also be used. By way of this measure a minimum throughflow cross-section for a fluid can be guaranteed. The third example of embodiment is particularly suitable for transmitting a pressure, for example via a fluid column which has bends. In this case large quantities of fluid do not have to flow

through the cross-section of the at least one plastic pipe 13. The function consists in the fact that the fluid column is not interrupted and the gravitational pressure it produces is essentially proportional to the height of the column.

Figs. 13 and 14 show how the anti-buckling device according to the invention functions in thin-walled ducts 6 such as hoses 14 or cores 15, which are made of textile gas or liquid-tight materials, inserted in woven materials

Fig. 13a shows the anti-buckling device in a duct 6 or a hose 14 at the buckling point 8. The cross-section is essentially lenticular and a fluid can move through the grooves. At the buckling point 8 the duct wall 9 essentially forms the envelope 4 and does not penetrate into the grooves 3. In the same way the area of the envelope 4 essentially constitutes the minimum cross-section area which a bent thin-walled duct 6 can assume at the buckling point 8 with an inserted anti-buckling device 1.

The cross-section shown in fig. 13b is to be positioned before and after the buckling point 8. The cross-section is essentially circular and with increasing distance from the buckling point 8 corresponds to the original cross-section of the duct 6 or hose 14. The anti-buckling device 1 with a lenticular cross-section is slightly deformed thereby. Pneumatic aircraft seats (CH 1428/92), for example, can utilise this type of anti-buckling device.

Figures 14a, b show cross-sections of a core 15 in a woven material 16. A third example of embodiment with a single plastic pipe 13 is shown as the anti-buckling device. At the buckling point 8 the cross-section, as has already been stated, is essentially lenticular and the duct wall 9 forms the envelope (fig. 14a). The plastic pipe 13 in turn

guarantees a minimum throughflow cross-section in the middle of the anti-buckling device1.

Fig. 14b also shows a cross-section before and after the buckling point 8. This cross-section is essentially circular, like the one in fig. 13b. However, as the core 15 is in a woven material 16, and as through shortening of the diameter D in the woven material level to D′ stresses σ [N/m] are introduced into the woven material, a force is required to achieve the circular cross-section. This force can be produced with an excess pressure ρ in the wire 15. The excess pressure ρ is attained by the application of pressure to the core or simply through the gravitational force of a column of liquid. In this way the anti-buckling device can be used in G-suits (EP 0 983 190) in order to prevent buckling of fluid-filled cores in the hip, knee and elbow joint regions and to guarantee that the height of the liquid column essentially corresponds to the difference in height between pilot′s neck and ankles.

Figs. 15a, b, essentially show the same configuration as figs. 14a, b. The anti-buckling device 1 is dimensioned here so that it is not deformed by changes in the cross-section. The width of the cross-section thus approximately corresponds to the diameter D′. This type of configuration can of course also be used in a duct 6 or in a hose 14.